

WHAT IS CLAIMED IS:

1. A method for manufacturing a copper foil having very low roughness, the method comprising the steps of:

5 pickling a copper foil (40) manufactured by electrodeposition and mechanical rolling within an acid pickling bath 100 containing an acid solution (100a) (S1000);

electrolytic polishing the copper foil through electrolysis by applying a positive current to the copper foil (40) and by applying a negative current to the cathode plate (210) with dipping the copper foil (40) to face a cathode plate (210) within at least one electrolytic polishing bath (200) installed with the cathode plate and containing a  
10 electrolytic polishing solution (200a) (S2000); and

washing the polished copper foil (40) within a water washing bath (300) containing water (S3000).

15 2. The method according to claim 1, wherein the electrolytic polishing solution (200a) is selected one or at least two from the group consisting of phosphoric acid, sulfuric acid, hydrochloric acid, nitric acid and boric acid.

3. The method according to claim 2, wherein the electrolytic polishing  
20 solution (200a) further comprises a corrosion inhibitor formed of one or at least two combinations selected from the group consisting of chromic acid, urea, mercaptan, and sulfur compounds.

4. The method according to claim 1, wherein the electrolytic polishing  
25 solution (200a) has an acidity within a range of 2.0 to 3.5

5. The method according to claim 1, wherein the electrolytic polishing step is performed in the electrolytic polishing solution having a temperature of 20 to 90°C.

5 6. The method according to claim 1, wherein the electrolytic polishing step is performed at a current density of 10 to 70 A/dm<sup>2</sup>.

7. The method according to claim 1, wherein the electrolytic polishing step is performed during 20 to 120 seconds per one electrolytic polishing bath (200).

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8. The method according to claim 1, wherein the electrolytic polishing step is performed with the electrolytic polishing solution (200a) having a laminar flow on the surface of the copper foil (40).

15 9. The method according to claim 1, wherein the electrolytic polishing step is performed by installing the cathode plate (210) to face a matt side of the copper foil having a relatively high roughness.

10 10. The method according to claim 1, wherein the electrolytic polishing step is performed by arranging alternately the electrolytic polishing bath (200) having the cathode plate (210) installed to face only the matt side of the copper foil and the electrolytic polishing bath (200) having the cathode plate (210) installed to face only the shiny side of the copper foil.

25 11. The method according to claim 1, wherein the method further comprises

a nodulating step for dipping the polished copper foil within a plating bath (400) containing a plating solution (400a) to form a nodule on the polished copper foil.

12. The method according to claim 11, wherein the plating solution (400a) is  
5 made by adding one or at least two elements selected from the group consisting of As, Fe, Mo, and Cr to a mixed solution consisting of Cu, H<sub>2</sub>O and H<sub>2</sub>SO<sub>4</sub>.

13. The method according to claim 1, wherein the method further comprises  
a post-process step for electrodepositing one or at least two elements selected from the  
10 group consisting of Zn, Cr, Co, Ni, Mo, W, Sn, and Fe on the copper foil (40).

14. The method according to claim 1, wherein the electrolytic polishing step  
polishes the copper foil precisely as the temperature of the electrolytic polishing solution  
(200a) within a plurality of baths (200) is set to be lower according to the direction of the  
15 arrangement of the baths, which is the same as the proceeding direction of the copper  
foil.

15. The method according to claim 1, wherein the electrolytic polishing step  
polishes the copper foil precisely as the acidity (pH) of the electrolytic polishing solution  
20 (200a) within a plurality of baths (200) is set to be higher according to the direction of  
the arrangement of the baths, which is the same as the proceeding direction of the  
copper foil.

16. The method according to claim 1, wherein the electrolytic polishing step  
25 polishes the copper foil precisely as the concentration of the corrosion inhibitor added to

the electrolytic polishing solution (200a) within a plurality of baths (200) is set to higher according to the direction of the arrangement of the baths, which is the same as the proceeding direction of the copper foil.

5           17.     The method according to claim 16, wherein the corrosion inhibitor includes one or at least two chemical compounds selected from the group consisting of chromic acid, urea, mercaptan, and sulfur compounds.

10           18.     The method according to claim 1, wherein the acid solution (100a) includes one selected from the group consisting of sulfuric acid of pH 5.0 or less, hydrochloric acid of pH 5.0 or less, and a mixed solution of sulfuric acid of pH 5.0 or less and hydrochloric acid of pH 5.0 or less.

15           19.     A copper foil having a low roughness treated by the method according to any one of claims 1 to 18.

20           20.     An apparatus for manufacturing a copper foil having very low roughness comprising:

an acid pickling bath (100) polishing a copper foil (40) using an acid solution (100a);

one or at least two electrolytic polishing baths (200) installed adjacent to the acid pickling bath (100) for polishing the copper foil (40) using an electrolytic polishing solution (200a);

a water washing bath (300) installed adjacent to the electrolytic polishing bath (200) for washing the copper foil (40) using water;

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a plurality of dipping rollers (500) installed within each of the baths (100, 200 and 300) for serially guiding the copper foil (40) into/from each bath;

a plurality of outside rollers (510) installed at the outside of each of the baths (100, 200 and 300) for guiding the copper foil (40) are geared with the dipping rollers (500); and

a cathode plates (210) installed to face a matt side of the copper foil having a relatively high surface roughness. Here, the cathode plates (210) are apart from the surface of the rollers with predetermined intervals within the electrolytic polishing bath (200) and also are connected to a cathode electrode of the power supply.

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21. The apparatus according to claim 20, wherein the apparatus further comprises an electrolytic polishing bath (200) including a cathode plate (210) installed to face a shiny side of the copper foil having a relatively low roughness.

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22. The apparatus according to claim 20, wherein the apparatus further comprises a solution supplying nozzle device (600) for supplying the electrolytic polishing solution 200a to the same direction as the processing direction of the copper foil (40).

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23. The apparatus according to claim 20, wherein the apparatus further comprises a plating bath (400) installed adjacent to the water washing bath (300) for forming a nodule on the polished copper foil using a plating solution (400a).